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Wen et al.

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(54) **WIRELESS STATION, COMMUNICATION SYSTEM, AND COMMUNICATION METHOD**

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(51) **Int. Cl.**

H04W 76/02	(2009.01)
H04L 1/18	(2006.01)
H04W 74/08	(2009.01)
H04W 84/18	(2009.01)
H04L 1/00	(2006.01)
H04W 76/04	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 76/027*** (2013.01); ***H04L 1/188*** (2013.01); ***H04W 74/08*** (2013.01); *H04L 2001/0092* (2013.01); *H04W 76/048* (2013.01); *H04W 84/18* (2013.01)

(58) **Field of Classification Search**

CPC G01S 3/02; G06F 15/16; H04M 11/04; H04W 24/00; H04W 40/00; H04W 76/027; H04W 84/02

See application file for complete search history.

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(57) **ABSTRACT**

A second wireless station includes a communicating unit that transmits a packet to a first wireless station and retransmits the packet when a response signal for the packet is not received by a predetermined response time limit; an acquiring unit that acquires from the first wireless station, transmission prohibition period information indicating a transmission prohibition period during which transmission of a signal by the first wireless station is prohibited; and a postponing unit that postpones the response time limit in the transmission prohibition period indicated by the acquired transmission prohibition period information to be after the transmission prohibition period ends.

10 Claims, 8 Drawing Sheets

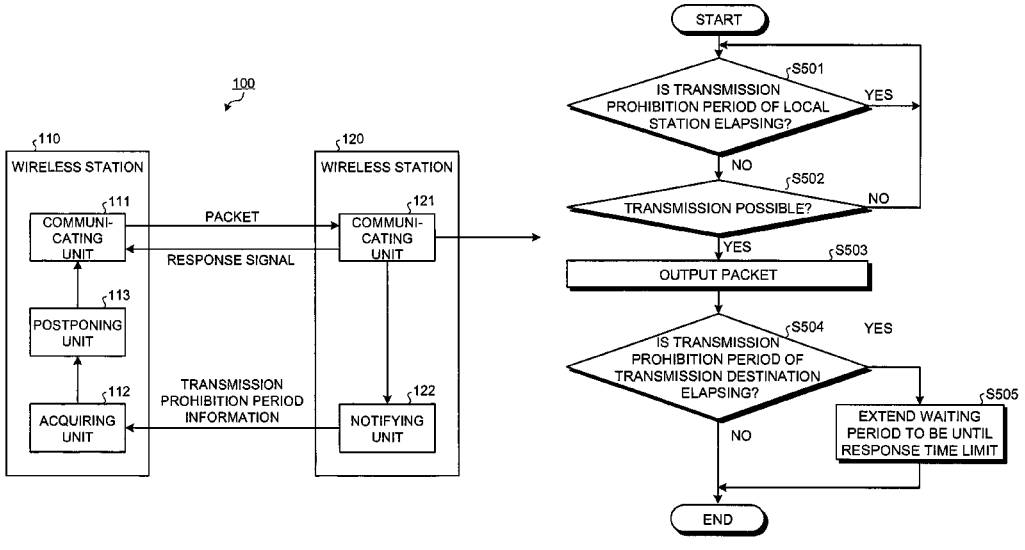

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FIG.1

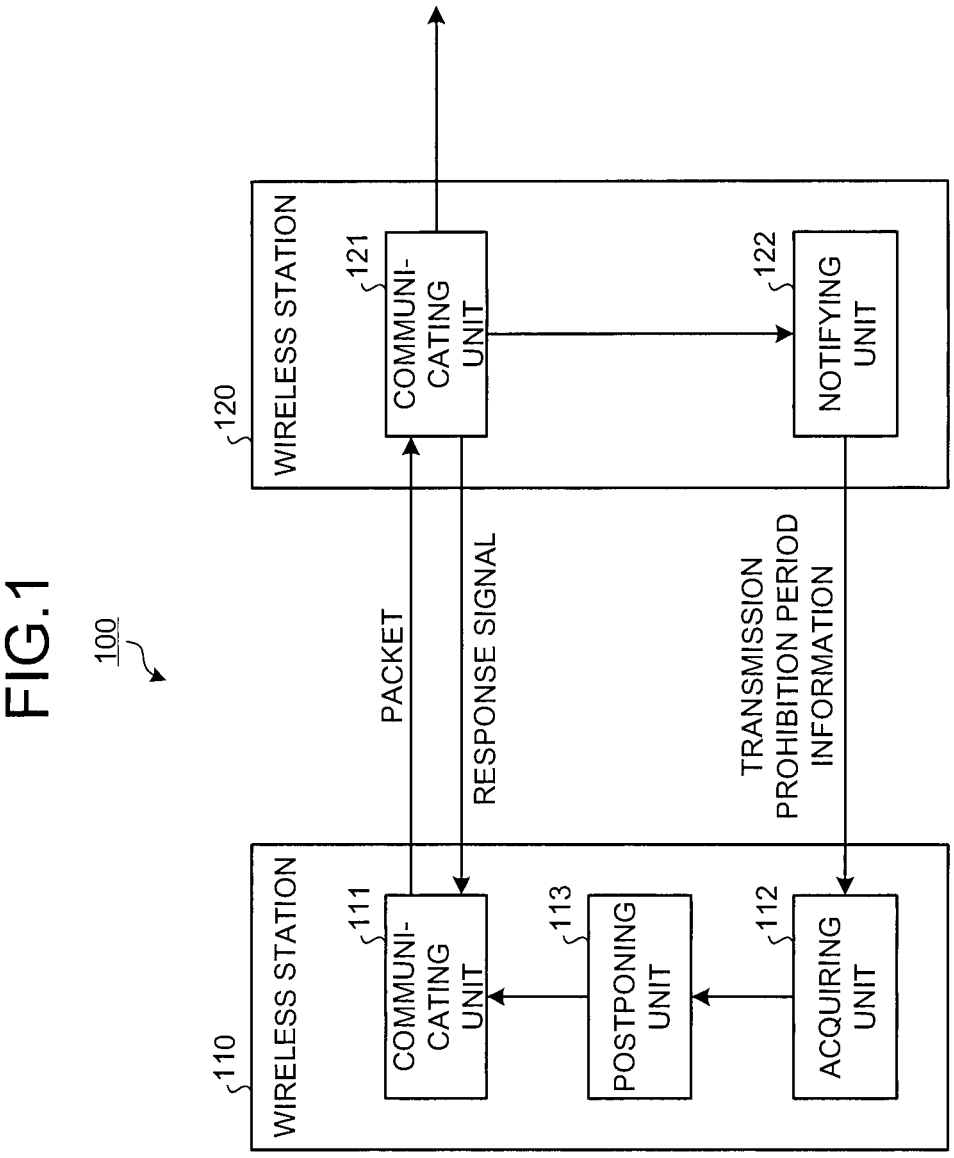

100
WIRELESS STATION
110
COMMUNI-CATING UNIT
111
POSTPONING UNIT
113
ACQUIRING UNIT
112
WIRELESS STATION
120
COMMUNI-CATING UNIT
121
NOTIFYING UNIT
122
PACKET
RESPONSE SIGNAL
TRANSMISSION PROHIBITION PERIOD INFORMATION

FIG.2

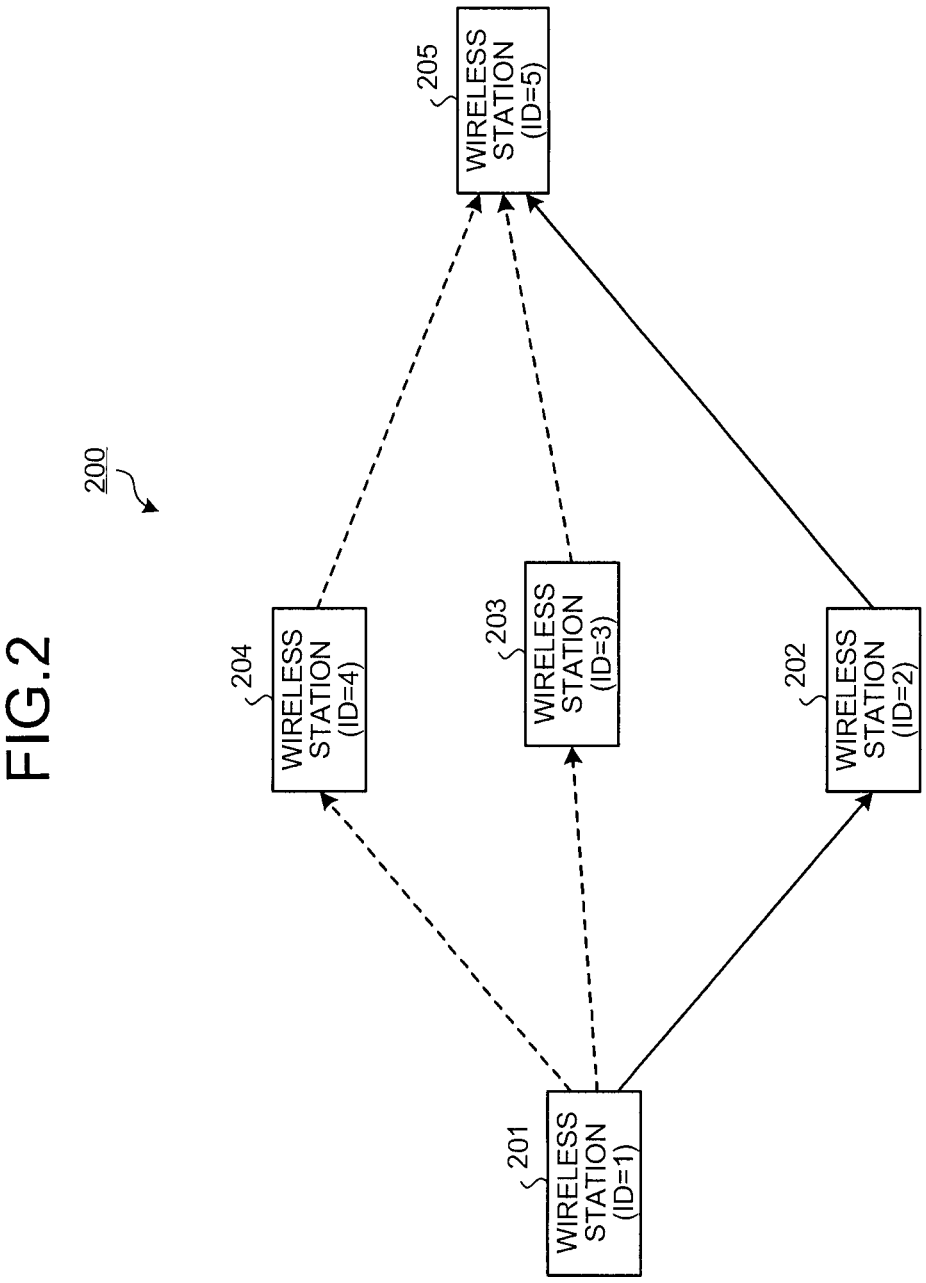

200
205
WIRELESS STATION (ID=5)
204
WIRELESS STATION (ID=4)
203
WIRELESS STATION (ID=3)
202
WIRELESS STATION (ID=2)
201
WIRELESS STATION (ID=1)

FIG.3

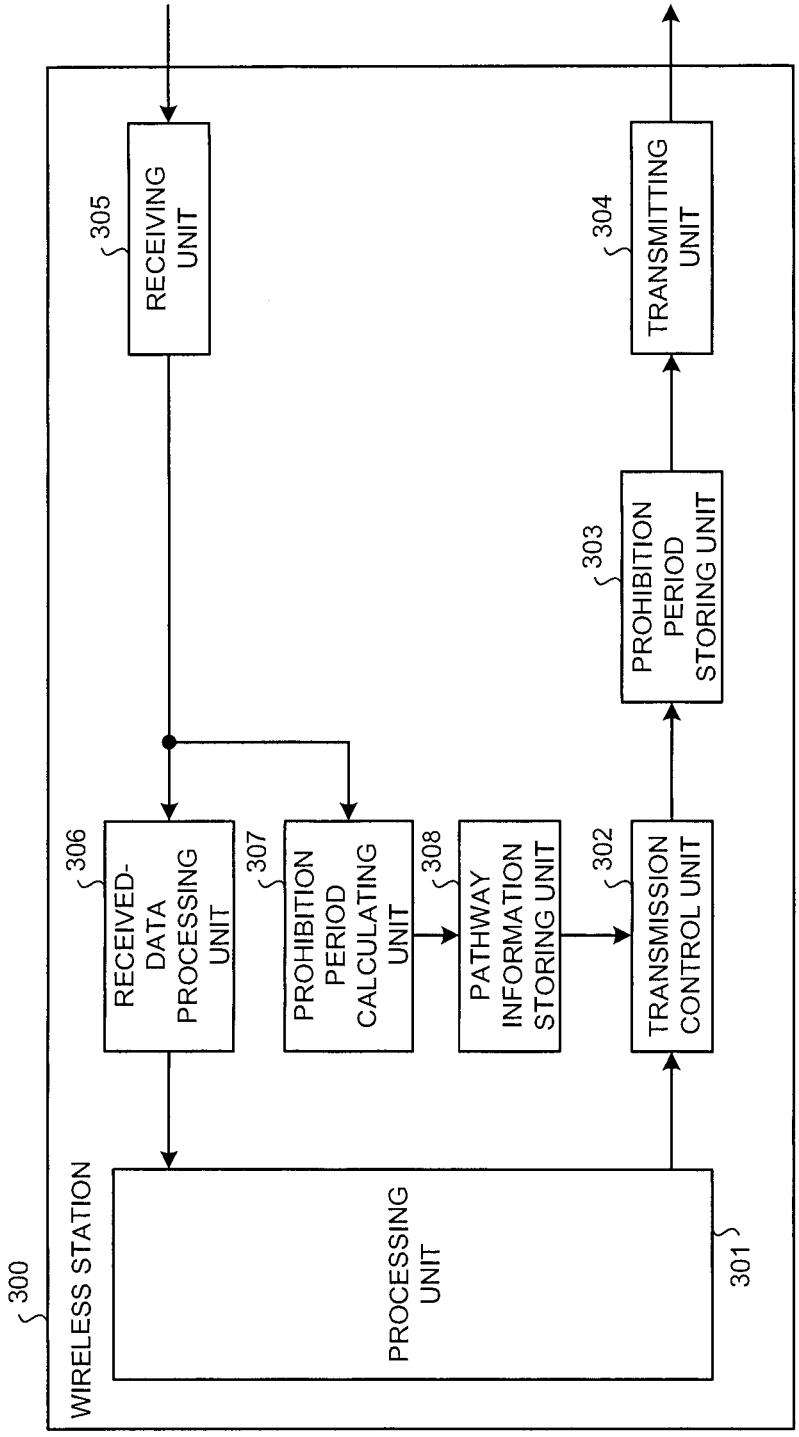

300
WIRELESS STATION
PROCESSING UNIT
301
RECEIVED-DATA PROCESSING UNIT
306
PROHIBITION PERIOD CALCULATING UNIT
307
PATHWAY INFORMATION STORING UNIT
308
TRANSMISSION CONTROL UNIT
302
PROHIBITION PERIOD STORING UNIT
303
RECEIVING UNIT
305
TRANSMITTING UNIT
304

FIG.4

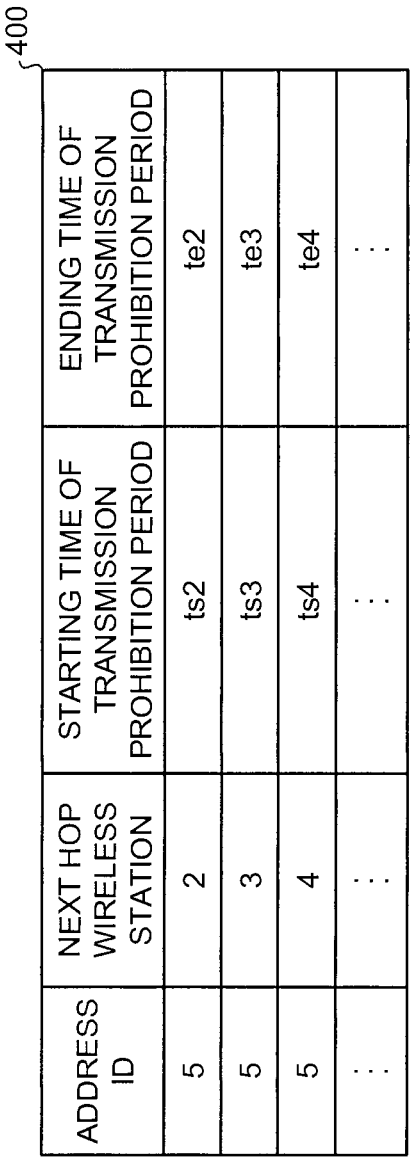

400
ADDRESS ID
NEXT HOP WIRELESS STATION
STARTING TIME OF TRANSMISSION PROHIBITION PERIOD
ENDING TIME OF TRANSMISSION PROHIBITION PERIOD
5
2
ts2
te2
5
3
ts3
te3
5
4
ts4
te4

FIG.5

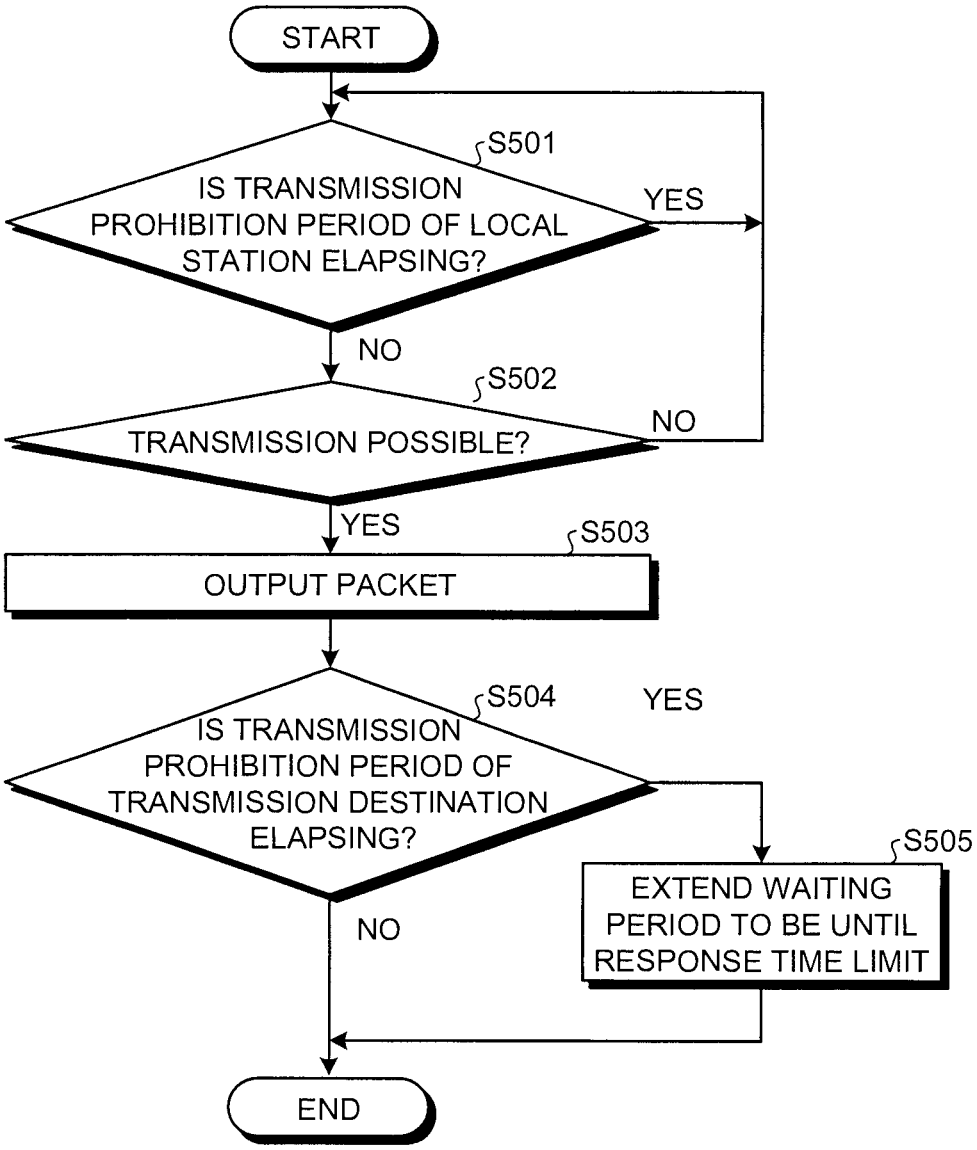

START
S501
IS TRANSMISSION PROHIBITION PERIOD OF LOCAL STATION ELAPSING?
YES
NO
S502
TRANSMISSION POSSIBLE?
NO
YES
S503
OUTPUT PACKET
S504
IS TRANSMISSION PROHIBITION PERIOD OF TRANSMISSION DESTINATION ELAPSING?
YES
NO
S505
EXTEND WAITING PERIOD TO BE UNTIL RESPONSE TIME LIMIT
END

FIG.6

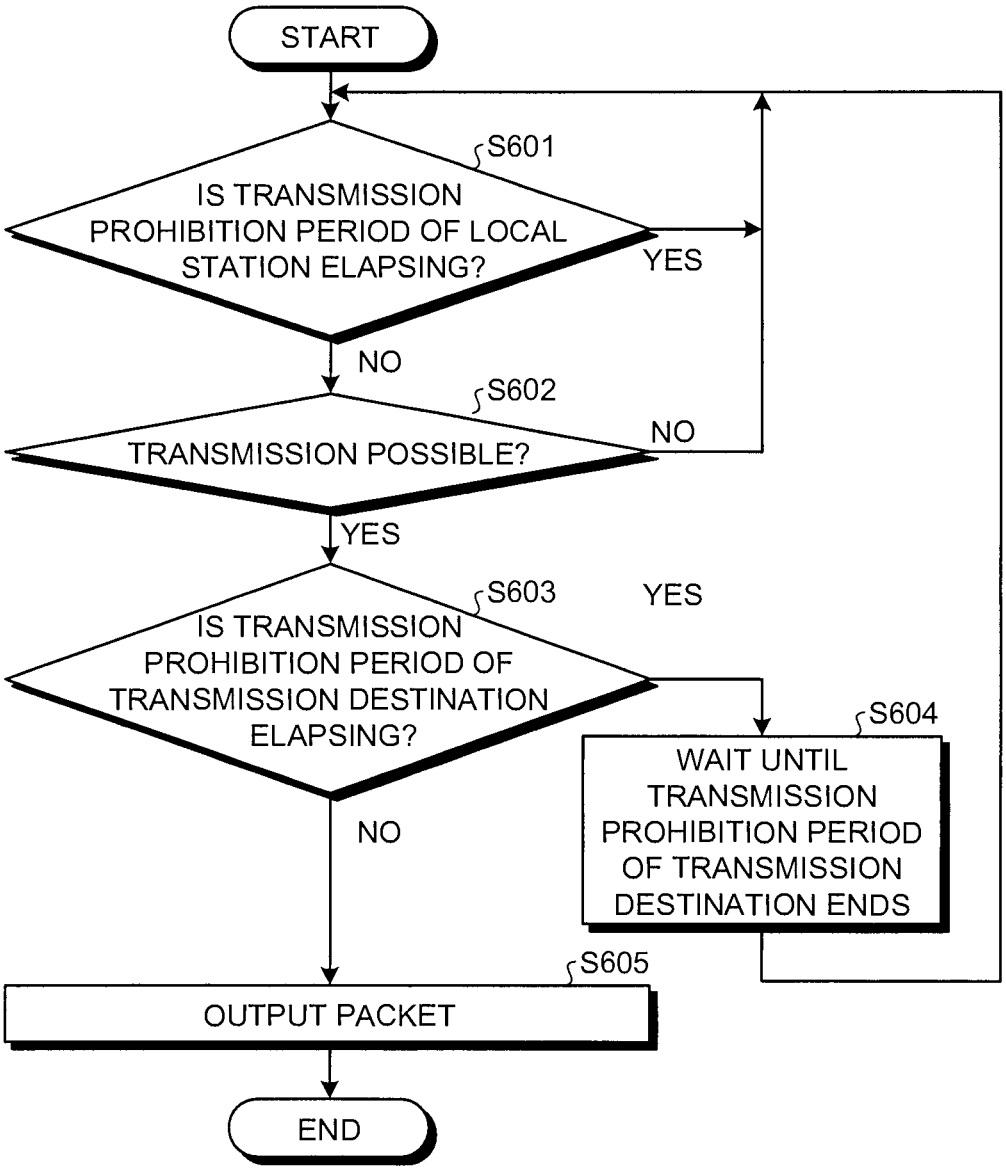

START
S601
IS TRANSMISSION PROHIBITION PERIOD OF LOCAL STATION ELAPSING?
YES
NO
S602
TRANSMISSION POSSIBLE?
NO
YES
S603
IS TRANSMISSION PROHIBITION PERIOD OF TRANSMISSION DESTINATION ELAPSING?
YES
NO
S604
WAIT UNTIL TRANSMISSION PROHIBITION PERIOD OF TRANSMISSION DESTINATION ENDS
S605
OUTPUT PACKET
END

FIG.7A

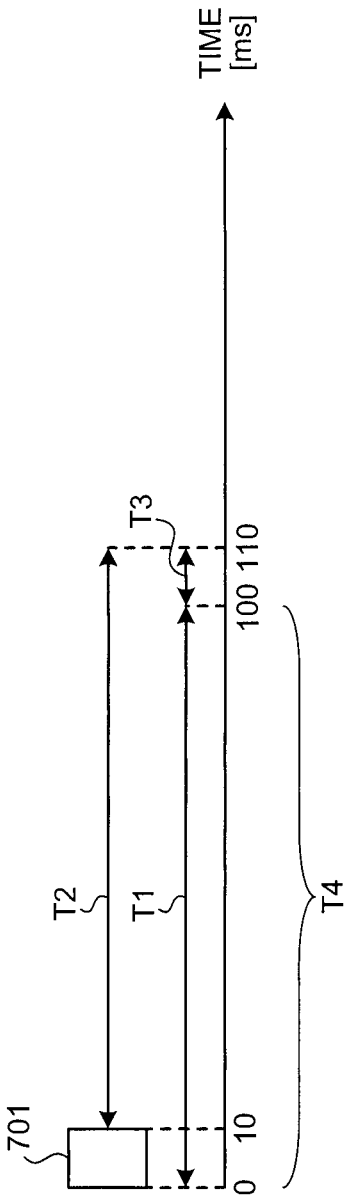

TIME [ms]
T3
100 110
T2
T1
T4
701
0 10

FIG.7B

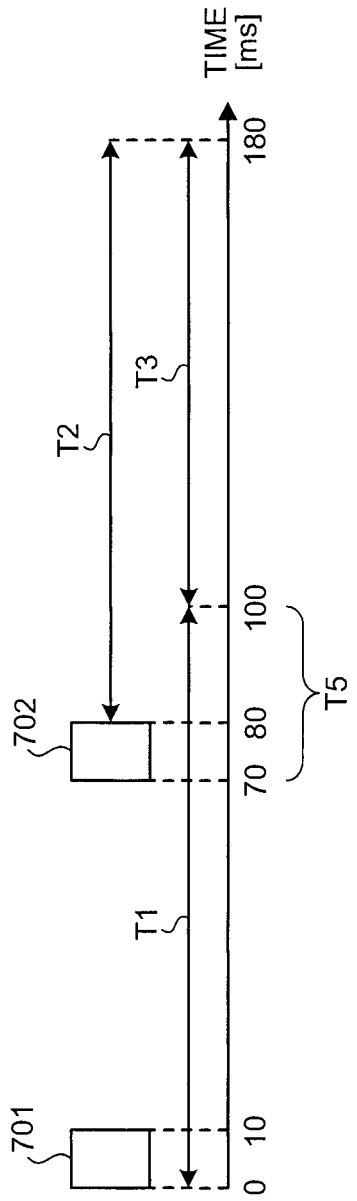

TIME [ms]
180
T3
T2
100
T5
702
70 80
T1
701
0 10

FIG.8A

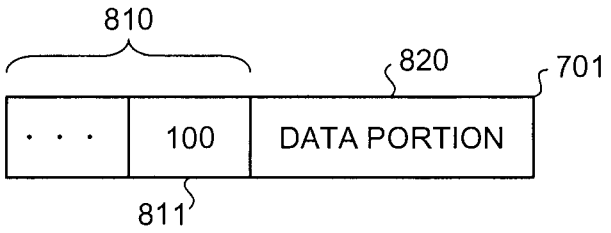
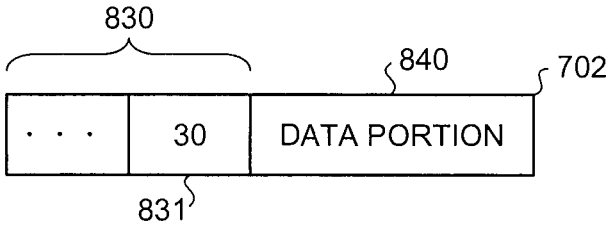

810
820
701
· · ·
100
DATA PORTION
811

FIG.8B


830
840
702
· · ·
30
DATA PORTION
831

WIRELESS STATION, COMMUNICATION SYSTEM, AND COMMUNICATION METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of International Application PCT/JP2010/067590, filed on Oct. 6, 2010 and designating the U.S., the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to a wireless station, a communication system, and a communication method that perform wireless communication.

BACKGROUND

Recently, a wireless ad hoc network (self-configuring network) linking plural wireless stations by wireless communication is under investigation. In the wireless ad hoc network, a transmitting wireless station transmits a packet to a receiving wireless station and confirms the success of the transmission by receiving a response signal (Ack) transmitted from the receiving wireless station.

If no response signal has been received even after a given waiting period has elapsed, the transmitting wireless station judges the transmission to be unsuccessful and retransmits the packet. If an optimum pathway and an alternative pathway are present for one address, and no response signal is received even after the packet has been retransmitted a number of times to the wireless station via the optimum pathway, the transmitting wireless station switches the pathway and transmits the packet to the wireless station via the alternative pathway.

Depending on the radio wave frequency to be used (e.g., 950 [MHz] band), there is a legal regulation of setting a transmission prohibition period during which signal transmission is prohibited after the transmission by the wireless station. When each wireless station has an active period in which transmission/reception is possible and a sleep period in which the transmission/reception is not possible, a technology is known of synchronizing so that each wireless station will have an active period common with an adjacent wireless station (see, e.g., Japanese Laid-Open Patent Publication No. 2009-296215). The wireless stations perform synchronization, for example, by transmitting/receiving a synchronization packet periodically.

In the wireless ad hoc network, since the transmitting timings of the wireless stations are asynchronous and the transmission prohibition periods of the wireless stations are also asynchronous, a packet may be transmitted to a wireless station during the transmission prohibition period. In this case, even if the packet is successfully received, the receiving wireless station cannot transmit a response signal and as a result, the transmitting wireless station retransmits the properly received data. Consequently, a problem arises in that traffic increases and throughput of the network decreases.

With the technology of synchronizing wireless stations by periodic transmission of synchronization packets, a problem arises in that the synchronization packets increase traffic and lower network throughput. Since the transmission prohibition period is set so that the wireless stations will synchronize with each other, the transmission prohibition period becomes longer than regulated, resulting in a delay in the transmission of the packet and lowered throughput.

SUMMARY

According to an aspect of an embodiment, a second wireless station includes a communicating unit that transmits a packet to a first wireless station and retransmits the packet when a response signal for the packet is not received by a predetermined response time limit; an acquiring unit that acquires from the first wireless station, transmission prohibition period information indicating a transmission prohibition period during which transmission of a signal by the first wireless station is prohibited; and a postponing unit that postpones the response time limit in the transmission prohibition period indicated by the acquired transmission prohibition period information to be after the transmission prohibition period ends.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** depicts a communication system according to a first embodiment;

FIG. **2** depicts one example of the communication system;

FIG. **3** depicts one example of a wireless station;

FIG. **4** depicts one example of pathway information;

FIG. **5** is a flowchart of a processing example of a transmission control unit according to the first embodiment;

FIG. **6** is a flowchart of a processing example of the transmission control unit according to a second embodiment;

FIG. **7**A depicts a first setting example of a transmission prohibition period;

FIG. **7**B depicts a second setting example of the transmission prohibition period;

FIG. **8**A depicts one example of transmission prohibition period information to be transmitted by first setting example; and

FIG. **8**B depicts one example of the transmission prohibition period information to be transmitted by second setting example.

DESCRIPTION OF EMBODIMENTS

Preferred embodiments will be described in detail with reference to the accompanying drawings.

FIG. **1** depicts a communication system according to a first embodiment. A communication system **100** depicted in FIG. includes a wireless station **110** (second wireless station) and a wireless station **120** (first wireless station). The wireless station **110** and the wireless station **120** are respectively communication devices that perform wireless communication. Mainly, a configuration will be described for transmitting a packet from the wireless station **110** to the wireless station **120**. The wireless station **110** has a communicating unit **111**, an acquiring unit **112**, and a postponing unit **113**.

The communicating unit **111** transmits a packet to the wireless station **120** (other wireless station). The communicating unit **111** retransmits the packet if the communicating unit **111** does not receive from the wireless station **120** and within a predetermined response time limit, a response signal (Ack) in response to the packet transmitted to the wireless station **120**. For example, the communicating unit **111** sets a period from the transmission of the packet until the time at which a given waiting period ends as a response period.

Retransmission of the packet is, for example, the retransmission to the wireless station **120** to which the packet was transmitted. When there is a packet transmission pathway other than that to the wireless station **120**, the packet may be retransmitted to the other transmission pathway.

The acquiring unit **112** acquires from the wireless station **120**, a transmission prohibition period during which signal transmission by the wireless station **120** is prohibited. For example, the acquiring unit **112** acquires from the wireless station **120**, transmission prohibition period information directly or indirectly indicating the transmission prohibition period of the wireless station **120**. The acquiring unit **112** notifies the postponing unit **113** of the transmission prohibition period indicated by the acquired transmission prohibition period information.

The postponing unit **113** postpones the response time limit of the communicating unit **111** in the transmission prohibition period notified by the acquiring unit **112** to be after the end of the transmission prohibition period. For example, if a request to transmit the packet at the communicating unit **111** occurs during the transmission prohibition period of the wireless station **120**, the postponing unit **113** postpones the response time limit of the communicating unit **111** to be after the end of the transmission prohibition period.

For example, the communicating unit **111** transmits the packet even during the transmission prohibition period of the wireless station **120** and the postponing unit **113** extends the waiting period from the transmission of the packet by the communicating unit **111** until the response time limit, thereby making it possible to postpone the response time limit of the communicating unit **111** to be after the end of the transmission prohibition period. Transmission of the packet during the transmission prohibition period of the wireless station **120** enables the packet to be transmitted efficiently. Consequently, a situation can be prevented in which, for example, at the time when the transmission prohibition period of the wireless station **120** ends, the transmission prohibition period of the wireless station **110** begins and the packet cannot be transmitted from the wireless station **110**.

The wireless station **120** has a communicating unit **121** and a notifying unit **122**. The communicating unit **121** transmits to the wireless station **110** (other wireless station) the response signal to the packet received from the wireless station **110**. The communicating unit **121** also transmits the packet from the wireless station **120** (local station) to other wireless stations. A transmission destination of the packet from the wireless station **120** may be the wireless station **110** or a wireless station different from the wireless station **110**.

In the case of transmission of the packet to another wireless station, the communicating unit **121** sets the transmission prohibition period during which signal transmission by the wireless station **120** is prohibited. The communicating unit **121** does not transmit the packet to other wireless stations during the set transmission prohibition period. In the case of reception of a packet from the wireless station **110** during the set transmission prohibition period, the communication unit **121** transmits a response signal to the wireless station **110** when the transmission prohibition period ends.

The communicating unit **121** notifies the notifying unit **122** of the set transmission prohibition period. The notifying unit **122** notifies the wireless stations around the wireless station **120** of the transmission prohibition period notified by the communicating unit **121**. For example, the notifying unit **122** distributes transmission prohibition period information that directly or indirectly indicates the transmission prohibition period. The wireless stations around the wireless station **120** are wireless stations capable of performing direct wireless communication with the wireless station **120**, including the wireless station **110**.

For example, the notifying unit **122** gives notification of the transmission prohibition period, which is set consequent to packet transmission by the wireless station **120**, concurrently with the transmission of a packet from the wireless station **120**. Thus, before the start of the transmission prohibition period, it is possible to assuredly give notification of the transmission prohibition period, which is set consequent to packet transmission.

The notifying unit **122** may given notification of the transmission prohibition period by way of the communicating unit **121**. For example, the notifying unit **122** may store the transmission prohibition period information in a packet from the wireless station **120** to be transmitted by the communicating unit **121**. Thereby making it possible to give notification of the transmission prohibition period to the wireless station that is the transmission destination of the packet to be transmitted from the communicating unit **121**. Notification of the transmission prohibition period can be given to wireless stations other than the transmission destination of the packet to be transmitted from the communicating unit **121** by having the packet to be transmitted from the communicating unit **121** monitored by the wireless stations.

Since notification of the transmission prohibition period can be given without generating a new packet to transmit the transmission prohibition period information, increases in the traffic can be suppressed. Thus, a situation in which the transmission prohibition period of the wireless station **120** is caused to occur more often or is extended by the transmission of a new packet for giving notification of the transmission prohibition period can be prevented.

The notifying unit **122** may store the transmission prohibition period information into a header portion of the packet to be transmitted from the communication unit **121**, whereby the transmission prohibition period information can be obtained by reading merely the header portion of the packet without decoding a data portion and as a result, wireless stations other than the transmission destination of the packet can easily acquire the transmission prohibition period information.

FIG. **2** depicts one example of the communication system. As depicted in FIG. **2**, a communication system **200** includes wireless stations **201** to **205** and is an independent and distributed wireless network (ad hoc network), where the wireless stations **201** to **205** are interlinked by the wireless communication. Each of the wireless stations **201** to **205** is a wireless station capable of the wireless communication. The wireless stations **201** to **205** are given IDs of "1" to "5", respectively.

For example, when the wireless station **201** transmits a packet addressed to the wireless station **205**, it is assumed that there are three pathways through the wireless stations **202** to **204**. The wireless station **201** transmits to any of the wireless stations **202** to **204**, a packet addressed to the wireless station **205**. The wireless station that receives the packet addressed to the wireless station **205** from the wireless station **201**, among the wireless stations **202** to **204**, transfers the received packet to the wireless station **205**.

In each link among the wireless stations **201** to **205**, a retransmission control is performed by which the packet is transmitted again, when no response signal is received even after the response time limit subsequent to a given period after the transmission of the packet. Retransmission control of the packet includes retransmission control by transmitting the packet again to the wireless station to which the packet was

transmitted and retransmission control by transmitting (pathway switching) the packet again to a pathway different from the wireless station to which the packet was transmitted.

The communication system **100** depicted in FIG. **1** can be applied to each link among the wireless stations **201** to **205**. For example, each of the wireless stations **201** to **205** has the function of the wireless station **110** and the wireless station **120**. For example, the wireless station **202** notifies surrounding wireless stations (e.g., wireless stations **201**, **203**, **205**, etc.) of the transmission prohibition period of the wireless station **202**. The wireless station **201**, in transmitting the packet to the wireless station **202**, postpones the response time limit in the transmission prohibition period of the wireless station **202** notified by the wireless station **202** to be after the end of the transmission prohibition period.

Thus, the wireless station **201** can be prevented from performing the retransmission control because of an inability of the wireless station **202** to transmit a signal in response to the packet from the wireless station **201** due to the transmission prohibition period. For example, a situation can be prevented in which the packet is transmitted again from the wireless station **201** to the wireless station **202** or the packet is retransmitted (pathway switched) from the wireless station **201** to the wireless station **203** or the wireless station **204** so that the packet is transmitted by plural pathways.

FIG. **3** depicts one example of the wireless station. A wireless station **300** is, for example, a wireless station applicable to each of the wireless stations **201** to **205** depicted in FIG. **2**. The wireless station **300** is a wireless station having the functions of the wireless station **110** and the wireless station **120** depicted in FIG. **1**. The wireless station **300** has a processing unit **301**, a transmission control unit **302**, a prohibition period storing unit **303**, a transmitting unit **304**, a receiving unit **305**, a received-data processing unit **306**, a prohibition period calculating unit **307**, and a pathway information storing unit **308**.

The communicating unit **111** of FIG. **1** can be realized by the processing unit **301**, the transmission control unit **302**, the transmitting unit **304**, the receiving unit **305**, and the received-data processing unit **306**. The acquiring unit **112** of FIG. **1** can be realized by the receiving unit **305** and the prohibition period calculating unit **307**. The postponing unit **113** of FIG. **1** can be realized by the transmission control unit **302** and the pathway information storing unit **308**. The communicating unit **121** of FIG. **1** can be realized by the processing unit **301**, the transmission control unit **302**, the transmitting unit **304**, the receiving unit **305**, and the received-data processing unit **306**. The notifying unit **122** of FIG. **1** can be realized by the prohibition period storing unit **303** and the transmitting unit **304**.

The processing unit **301** generates data to be transmitted from the wireless station **300** (local station) to other wireless stations and outputs the generated data to the transmission control unit **302**. The processing unit **301** also processes the data output from the received-data processing unit **306**. For example, the processing unit **301** generates a response signal (Ack) for the data output from the received-data processing unit **306** and outputs the response signal (Ack) to the transmission control unit **302**. The processing unit also transfers data having another station as a final address by outputting the data to the transmission control unit **302**.

The transmission control unit **302** performs transmission control of the data (including response signals) output from the processing unit **301**, based on the pathway information stored in the pathway information storing unit **308**. For example, the transmission control unit **302** acquires from the pathway information of the pathway information storing unit **308**, the next hop wireless station ID associated with an ID indicating the address of the data output from the processing unit **301**. The transmission control unit **302** generates a packet storing a header portion including the acquired next hop wireless station ID as a transmission destination and the data output from the processing unit **301**.

The transmission control unit **302** acquires from the pathway information of the pathway information storing unit **308**, the transmission prohibition period of the acquired next hop destination. The transmission control unit **302**, based on the acquired transmission prohibition period, postpones the response time limit for waiting for a signal in response to the generated packet. The transmission control unit **302** outputs the generated packet to the prohibition period storing unit **303**, whereby the packet output by the transmission control unit **302** is transmitted from the transmitting unit **304**.

After transmission of the packet, the transmission control unit **302** sets the transmission prohibition period during which the transmission of the packet from the wireless station **300** is prohibited. The packet based on the data output from the processing unit **301** during the transmission prohibition period is output by the transmission control unit **302** to the prohibition period storing unit **303** upon ending of the transmission prohibition period.

The prohibition period storing unit **303** stores the transmission prohibition period information indicating the transmission prohibition period of the wireless station **300** into the header portion of the packet output from the transmission control unit **302**. The prohibition period storing unit **303** outputs to the transmitting unit **304**, the packet storing the transmission prohibition period information. The transmitting unit **304** performs wireless transmission of the packet output from the prohibition period storing unit **303**.

The receiving unit **305** receives packets transmitted from wireless stations surrounding the wireless station **300**. The receiving unit **305** outputs the received packets to the received-data processing unit **306** and the prohibition period calculating unit **307**. The received-data processing unit **306** acquires the transmission destination of the packet, included in the header portion of the packet output from the receiving unit **305**. The received-data processing unit **306** discards packets having another station as a transmission destination as well as outputs to the processing unit **301**, the data stored in packets having the local station as a transmission destination.

The prohibition period calculating unit **307** acquires transmission prohibition period information included in the header portion of the packets output from the receiving unit **305**. This enables the prohibition period calculating unit **307** to acquire the transmission prohibition period information stored in the packet having the local station as a transmission destination as well as monitor the transmission prohibition period information stored in packets having another station as a transmission destination. The prohibition period calculating unit **307** calculates the transmission prohibition period of the transmission source of the packet, based on the acquired transmission prohibition period information. The prohibition period calculating unit **307** registers into the pathway information of the pathway information storing unit **308**, the calculated transmission prohibition period, in association with the wireless station as the transmission source of the packet.

The pathway information storing unit **308** stores the pathway information associating the address of the packet with the next hop destination (transmission destination). The pathway information stored in the pathway information storing unit **308** is sequentially updated depending on the wireless stations present around the wireless station **300**. Updating of the pathway information is performed, for example, by the

processing unit **301**. In the pathway information to be stored to the pathway information storing unit **308**, the next hop destination of each hop destination and the transmission prohibition period set for the next hop destination are associated.

FIG. **4** depicts one example of the pathway information. A table **400** depicted in FIG. **4** denotes an example of the pathway information to be stored to the pathway information storing unit **308** of the wireless station **201** depicted in FIG. **2**. The table **400** indicates the pathways having the wireless station **205** (ID=5) as the address. For example, for the wireless station **201**, there are three pathways having the wireless station **205** as the address and the next hop wireless station IDs of these pathways are "2", "3", and "4".

Therefore, when data having the wireless station **205** (ID-5) as the address is output from the processing unit **301**, the transmission control unit **302** determines any one of the wireless stations **202** to **204** as the transmission destination. In the table **400**, each next hop wireless station ID is associated with a starting time and an ending time of the transmission prohibition period. This enables the transmission control unit **302** to acquire the transmission prohibition period of the wireless station that is the transmission destination of the data.

FIG. **5** is a flowchart of a processing example of the transmission control unit according to the first embodiment. Upon output of the data from the processing unit **301**, the transmission control unit **302** executes operations, for example, depicted in FIG. **5**. The transmission control unit **302** first determines whether the transmission prohibition period of the local station is elapsing (step S**501**). If the transmission prohibition period of the local station is elapsing (step S**501**: YES), the transmission control unit **302** waits for the transmission prohibition period to end. If the transmission prohibition period of the local station has elapsed (step S**501**: NO), the transmission control unit **302** confirms slot availability of the local station and determines whether a packet including the data output from the processing unit **301** can be transmitted (step S**502**).

At step S**502**, if the packet cannot be transmitted (step S**502**: NO), the flow returns to step S**501**. If the packet including the data output from the processing unit **301** can be transmitted (step S**502**: YES), the transmission control unit **302** outputs the packet to the prohibition period storing unit **303** (step S**503**). Consequently, the prohibition period storing unit **303** stores the transmission prohibition period information of the local station into the header portion of the packet and the transmitting unit **304** transmits the packet.

The transmission control unit **302** determines whether the transmission prohibition period of the transmission destination (next hop destination) of the packet transmitted at step S**503** is elapsing (step S**504**). If the transmission prohibition period of the transmission destination has elapsed (step S**504**: NO), the transmission control unit **302** ends the series of operations. If the transmission prohibition period is elapsing the transmission destination (step S**504**: YES), the transmission control unit **302** extends the waiting period from the transmission of the packet at step S**503** until the response time limit (step S**505**), and end the series of operations. Thus, the response time limit of the packet transmitted at step S**503** is postponed.

The operations above enable the transmission of a packet to a transmission destination even during the transmission prohibition period of the transmission destination as well as the postponement of the response time limit by extending the waiting period, from the transmission of the packet until the response time limit.

At step S**505**, configuration may be such that if the ending time of the transmission prohibition period is later than the response time limit, the response time limit will be postponed and that if the ending time of the transmission prohibition period is earlier than the response time limit, the response time limit will not be postponed. If the response time limit is not postponed when the ending time of the transmission prohibition period is earlier than the response time limit, unnecessary postponing of the response time limit can be prevented. For example, if a response signal is not transmitted because of the transmitting destination not properly receiving the packet transmitted at step S**503**, a case of waiting for the response signal beyond the original response time limit can be prevented.

Thus, in the communication system **100** according to the first embodiment, the wireless station **120** notifies the wireless station **110** of the transmission prohibition period of the wireless station **120**. The wireless station **110** transmits packets to the wireless station **120** even during the transmission prohibition period of the wireless station **120** as well as postpones the response time limit by extending the waiting period, from the transmission of the packet by the wireless station **110** until the response time limit. As a result, retransmission of a properly received packet from the second wireless station can be prevented, improving the throughput of the network.

The communication system according to a second embodiment is identical to the communication system **100** depicted in FIG. **1**, except that when a request to transmit a packet at the communicating unit **111** occurs during the transmission prohibition period of the wireless station **120**, the postponing unit **113** of the wireless station **110** delays the transmission of the packet by the communicating unit **111**. Since this delays the starting point of the response time limit to be set for the communicating unit **111**, the response time limit of the communicating unit **111** can be postponed.

The postponing unit **113** may cause the transmission of the packet by the communication unit **111** to be postponed until after the transmission prohibition period of the wireless station **120** ends. Thus, the response time limit can be assuredly postponed to be after the ending of the transmission prohibition period of the wireless station **120**.

Examples of the communication system, the wireless station, and the pathway information according to the second embodiment are identical to the examples depicted in FIGS. **1** to **4**. A processing example of the transmission control unit **302** of the wireless station **300** according to the second embodiment will be described.

FIG. **6** is a flowchart of a processing example of the transmission control unit according to the second embodiment. Upon output of the data from the processing unit **301**, the transmission control unit **302** executes, for example, operations depicted in FIG. **6**. The transmission control unit **302** determines whether the transmission prohibition period of the local station is elapsing (step S**601**). If the transmission prohibition period is elapsing (step S**601**: YES), the transmission control unit **302** executes step S**601** again. If the transmission prohibition period has elapsed (step S**601**: NO), the transmission control unit **302** confirms slot availability of the local station and determines whether a packet including the data output from the processing unit **301** can be transmitted (step S**602**).

At step S**602**, if the packet cannot be transmitted (step S**602**: NO), the flow returns to step S**601**. If the packet can be transmitted (step S**602**: YES), the transmission control unit **302** determines whether the transmission prohibition period of the transmission destination (next hop destination) of the packet is elapsing (step S**603**). If the transmission prohibition period of the transmission destination is elapsing (step S**603**:

YES), the transmission control unit **302** waits until the transmission prohibition period of the transmission destination ends (step S**604**) and returns to step S**601**.

At step S**603**, if the transmission prohibition period of the transmission destination has elapsed (step S**603**: NO), the transmission control unit **302** outputs the packet to the prohibition period storing unit **303** (step S**605**), ending the series of operations. Thus, the prohibition period storing unit **303** stores the transmission prohibition period information of the local station into the header portion of the packet and the transmitting unit **304** transmits the packet. If the transmission prohibition period of the transmission destination of the packet is elapsing, the operations above enable the response time limit to be postponed by delaying the transmission of the packet until the end of the transmission prohibition period.

At steps S**603** and S**604**, configuration may be such that if the ending time of the transmission prohibition period is later than the response time limit, the response time limit is postponed and that if the ending time of the transmission prohibition period is earlier than the response time limit, the response time limit is not postponed. If the response time limit is not postponed when the ending time of the transmission prohibition period is earlier than the response time limit, unnecessary postponing of the response time limit can be prevented.

Thus, in the communication system **100** according to the second embodiment, the wireless station **120** notifies the wireless station **110** of the transmission prohibition period of the wireless station **120**. When a request to transmit a packet at the communicating unit **111** occurs in the transmission prohibition period of the wireless station **120**, the wireless station **110** postpones the response time limit of the communicating unit **111** by delaying the transmission of the packet by the communicating unit **111**. Thus, retransmission of a properly received packet from the second wireless station can be prevented, improving the throughput of the network.

Setting of the transmission prohibition period in for embodiment will be described.

FIG. **7**A depicts a first setting example of the transmission prohibition period. FIGS. **7**A and **7**B depict setting methods of the transmission prohibition period prescribed by regulations for 950 [MHz] band as one example. In FIGS. **7**A and **7**B, the horizontal axis represents time [ms].

A packet **701** is a first packet that the wireless station **300** transmits after startup or after the transmission prohibition period has ended. The transmission start time of the packet **701** is given as 0 [ms], the packet length (time required for transmission) of the packet **701** as 10 [ms]. Therefore, the transmission end time of the packet **701** is time 10 [ms].

As depicted in FIG. **7**A, the wireless station **300** sets a continuously transmittable period T**1** of a given length (given as 100 [ms]) from the transmission starting time (time 0 [ms]) of the packet **701**. The wireless station **300** sets a dormant period T**2** of a given length (given as 100 [ms]) from the transmission ending time (time 10 [ms]) of the packet **701**. If the wireless station **300** does not transmit a new packet during the dormant period T**2**, the wireless station **300** can transmit the new packet after the dormant period T**2** ends.

A transmission prohibition period T**3** during which the wireless station **300** is prohibited from transmitting a signal is from the ending time (time 100 [ms]) of the continuously transmittable period T**1** to the ending time (time 110 [ms]) of the dormant period T**2**. At the time of transmitting the packet **701**, the wireless station **300** calculates time T**4** from the transmission starting time (time 0 [ms]) of the packet **701** until time 100 [ms] when the continuously transmittable period T**1** ends, as the transmission prohibition period information of the local station. In this case, time T**4** is information that indirectly indicates the transmission prohibition period of the wireless station **300**.

In this example, time T**4**=100 [ms]−0 [ms]=100 [ms] is calculated as the transmission prohibition period information. The prohibition period storing unit **303** stores the calculated transmission prohibition period information into the packet **701** and transmits the packet **701**. This enables surrounding wireless stations that receive the packet **701** to calculate the transmission prohibition period T**3** of the wireless station **300** based on the transmission prohibition period information (time T**4**) included in the received packet **701**.

FIG. **7**B depicts a second setting example of the transmission prohibition period. As depicted in FIG. **7**B, when there is a data transmission request during the continuously transmittable period T**1** depicted in FIG. **7**A, the wireless station **300** can transmit a new packet **702** even during the dormant period T**2**. The transmission starting time of the packet **702** is given as time 70 [ms], the packet length of the packet **702** as 10 [ms]. Therefore, the transmission ending time of the packet **702** is time 80 [ms]. In this case, since a new dormant period T**2** is set from time 80 [ms] when the transmission of the packet **702** ends, the transmission prohibition period T**3** is extended.

At the time of transmitting the packet **702**, the wireless station **300** calculates time T**5** from the transmission starting time (time 70 [ms]) of the packet **702** until time 100 [ms] at which the continuously transmittable period T**1** ends, as the transmission prohibition period information of the local station. In this case, time T**5**=100 [ms]−70 [ms]=30 [ms] is calculated as the transmission prohibition period information.

The prohibition period storing unit **303** stores the calculated transmission prohibition period information into the packet **702** and transmits the packet **702**. This enables surrounding stations that receive the packet **702** to calculate the transmission prohibition period T**3** of the wireless station **300**, based on the transmission prohibition period information (time T**5**) included in the received packet **702**.

FIG. **8**A depicts one example of the transmission prohibition period information to be transmitted by first setting example. The packet **701** depicted in FIG. **8**A is the packet **701** depicted in FIG. **7**A. As depicted in FIG. **8**A, the packet **701** includes a header portion **810** and a data portion **820**. The wireless station **300** stores into the header portion **810** as the transmission prohibition period information of the local station, transmission prohibition period information **811** indicating the calculated time T**4**=100 [ms].

Each wireless station that is around the wireless station **300** and receives the packet **701** reads out the header portion **810** of the received packet **701** and calculates the transmission prohibition period T**3** of the wireless station **300**, based on the time T**4** indicated by the transmission prohibition period information **811** stored in the header portion **810**. It is assumed that the dormant period length (100 [ms]) is common to all wireless stations.

The starting time (time 100 [ms]) of the transmission prohibition period T**3** is calculated by packet **701** reception ending time+(time T**4**−packet length)=10 [ms]+(100 [ms]−10 [ms]). The ending time (time 110 [ms]) of the transmission prohibition period T**3** is calculated by packet **701** reception ending time+dormant period length=10 [ms]+100 [ms].

FIG. **8**B depicts one example of the transmission prohibition period information to be transmitted by second setting example. The packet **702** depicted in FIG. **8**B is the packet **702** depicted in FIG. **7**B. As depicted in FIG. **8**B, the packet **702** includes a header portion **830** and a data portion **840**. The

wireless station **300** stores into the header portion **830** as the transmission prohibition period information of the local station, transmission prohibition period information **831** indicating the calculated time T**5**=30 [ms].

Each wireless station that is around the wireless station **300** and receives the packet **702** reads out the header portion **830** of the received packet **702** and calculates the transmission prohibition period T**3** of the wireless station **300** based on the time T**5** indicated by the transmission prohibition period information **831** stored in the header portion **830**. It is assumed that the dormant period length (100 [ms]) is common to all wireless stations.

The starting time (time 100 [ms]) of the transmission prohibition period T**3** is calculated by packet **702** reception ending time+(time T**5**−packet length)=80 [ms]+(30 [ms]−10 [ms]). The ending time (time 180 [ms]) of the transmission prohibition period T**3** is calculated by packet **702** reception ending time+dormant period length=80 [ms]+100 [ms].

Thus, the wireless station **300** can distribute transmission prohibition period information that indirectly indicates the transmission prohibition period by taking the information (time T**4**/T**5**) indicating a relationship of transmitting timing of the packet storing the transmission prohibition period information and the transmission prohibition period as the transmission prohibition period information. A wireless station that receives the packet storing the transmission prohibition period information can calculate the transmission prohibition period of the wireless station **300**, based on the packet receiving timing and time T**4**/T**5**. Thus, wireless stations can share the transmission prohibition period with each other even if the wireless stations are asynchronous as in an ad hoc network.

As described, according to the disclosed wireless station, communication system, and communication method, the wireless station **110** can be notified of the transmission prohibition period of the wireless station **120** and the response time limit of the wireless station **110** during the transmission prohibition period of the wireless station **120** can be postponed to be after the transmission prohibition period ends. Thus, the retransmission of a properly received packet from the wireless station **110** can be prevented, improving the throughput of the network.

Since the response time limit is dynamically postponed according to the transmission prohibition period, it is unnecessary to set the transmission prohibition period so that the wireless stations will synchronize with each other and lengthening of the transmission prohibition period beyond regulatory requirements can be prevented, thereby further improving the throughput of the network.

The disclosed wireless station, communication system, and communication method enable improved network throughput.

All examples and conditional language provided herein are intended for pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A second wireless station comprising:

a communicating unit configured to transmit a packet to a first wireless station and retransmit the packet when a response signal for the packet from the first wireless station is not received by a predetermined response time limit;

an acquiring unit configured to obtain from the first wireless station transmission prohibition period information indicating a transmission prohibition period for the first wireless station, during which transmission of a signal by the first wireless station is prohibited; and

a postponing unit configured to:

extend the predetermined response time limit that was to expire in the transmission prohibition period indicated by the acquired transmission prohibition period information such that the predetermined response time limit expires after the transmission prohibition period ends; and

transmit the packet to the first wireless station during the transmission prohibition period of the first wireless station, wherein extending the predetermined response time limit comprises extending a waiting period from the transmission of the packet until the extended predetermined response time limit expires.

2. The second wireless station according to claim **1**, wherein the postponing unit is further configured to extend the predetermined response time limit if an ending of the transmission prohibition period of the first wireless station is later than the predetermined response time limit, and not extend the predetermined response time limit if the ending of the transmission prohibition period of the first wireless station is earlier than the predetermined response time limit.

3. The second wireless station according to claim **1**, wherein the acquiring unit is further configured to obtain the transmission prohibition period information included in the packet transmitted by the first wireless station.

4. The second wireless station according to claim **3**, wherein the acquiring unit is further configured to monitor a packet transmitted from the first wireless station to a wireless station other than the second wireless station and to obtain the transmission prohibition period information included in the monitored packet.

5. The second wireless station according to claim **1**, wherein the transmission prohibition period information for the first wireless station is included in a header of a packet transmitted from the first wireless station.

6. A communication system comprising:

a first wireless station; and

a second wireless station wirelessly coupled to the first wireless station, wherein:

the first wireless station is configured to transmit to the second wireless station, a response signal for a packet received from the second wireless station, and to notify surrounding wireless stations of a transmission prohibition period of the first wireless station, during which transmission of a signal by the first wireless station is prohibited; and

the second wireless station is configured to:

when the response signal for the packet transmitted to the first wireless station is not received by a predetermined response time limit, retransmit the packet and extend the predetermined response time limit that is to expire in the transmission prohibition period of the first wireless station such that the predetermined response time limit expires after the transmission prohibition period ends; and

transmit the packet to the first wireless station during the transmission prohibition period of the first wireless station, wherein extending the predetermined response time limit comprises extending a waiting period from the transmission of the packet until the extended predetermined response time limit expires.

7. The communication system according to claim **6**, wherein the transmission prohibition period information for the first wireless station is included in a header of a packet transmitted from the first wireless station.

8. A communication method that is executed by a first wireless station that transmits to a second wireless station, a response signal for a packet received from the second wireless station, and that is executed by the second wireless station that when the response signal to the packet transmitted to the first wireless station is not received by a predetermined response time limit, retransmits the packet, the communication method comprising:

at the first wireless station, notifying surrounding wireless stations of a transmission prohibition period of the first wireless station, during which the transmission of a signal by the first wireless station is prohibited; and

at the second wireless station, extending the predetermined response time limit that is to expire in the transmission prohibition period of the first wireless station, such that the predetermined response time lime expires after the transmission prohibition period ends, and

transmitting the packet to the first wireless station during the transmission prohibition period of the first wireless station, wherein extending the predetermined response time limit comprises extending a waiting period from the transmission of the packet until the extended predetermined response time limit expires.

9. The communication method according to claim **8**, further comprising:

at the second wireless station, obtaining from the first wireless station transmission prohibition period information indicating the transmission prohibition period for the first wireless station.

10. The communication method according to claim **8**, wherein the transmission prohibition period information for the first wireless station is included in a header of a packet transmitted from the first wireless station.

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